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Part II

Environmental Protection Agency

Stationary Internal Combustion Engines; Standards of Performance for New Stationary Sources and Addition to the List of Categories of Stationary Sources

ENVIRONMENTAL PROTECTION AGENCY

[FRL 1099-5]

[40 CFR Part 60]

Stationary Internal Combustion Engines; Standards of Performance for New Stationary Sources

AGENCY: Environmental Protection Agency (EPA).

ACTION: Proposed rule.

SUMMARY: The proposed standards, which would apply to facilities that commence construction 30 months after today's date, would limit emissions of nitrogen oxides (NO_x) from new, modified, and reconstructed stationary gas, diesel, and dual-fuel internal combustion (IC) engines to 700 parts per million (ppm), 600 ppm, 600 ppm, respectively at 15 percent oxygen (O_2) on a dry basis. A revision to Reference Method 20 for determining the concentration of nitrogen oxides and oxygen in the exhaust gases from large stationary IC engines is also proposed.

The standards implement the Clean Air Act and are based on the Administrator's determination that stationary IC engines contribute significantly to air pollution. The intent is to require new, modified, and reconstructed stationary IC engines to use the best demonstrated system of continuous emission reduction, considering costs, non-air quality health, and environmental and energy impacts.

A public hearing will be held to provide interested persons an opportunity for oral presentation of data, views, or arguments concerning the proposed standards.

DATES: *Comments.* Comments must be received on or before September 21, 1979.

Public Hearing. The public hearing will be held on August 22, 1979 beginning at 9:30 a.m. and ending at 4:30 p.m.

Request to Speak at Hearing. Persons wishing to attend the hearing or present oral testimony should contact EPA by August 15, 1979.

ADDRESSES: *Comments.* Comments should be submitted to Mr. Jack R. Farmer, Chief, Standards Development Branch (MD-13), Emission Standards and Engineering Division, Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

Public Hearing. The public hearing will be held at the Environmental Research Center Auditorium, Room B101, Research Triangle Park, N.C. 27711. Persons wishing to attend or present oral testimony should notify Mary Jane Clark, Emission Standards and Engineering Divison (MD-13), Environmental Protection Agency, Research Triangle Park, North Carolina 27711, telephone number (919) 541-5271.

Standards Support Document. The support document for the proposed standards may be obtained from the EPA Library (MD-35), Research Triangle Park, North Carolina 27711, telephone number (919) 541-2777. Please refer to "Standards Support and Environmental Impact Statement: Proposed Standards of Performance for Stationary Internal Combustion Engines," EPA-450/3-78-125a.

Docket. The Docket, number OAQPS-79-5, is available for public inspection and copying at the EPA's Central Docket Section, Room 2903 B, Waterside Mall, Washington, D.C. 20460.

FOR FURTHER INFORMATION CONTACT: Mr. Don R. Goodwin, Director, Emission Standards and Engineering Division (MD-13), Environmental Protection Agency, Research Triangle Park, North Carolina 27711, telephone (919) 541-5271.

SUPPLEMENTARY INFORMATION:

Proposed Standards

The proposed standards, which are summarized in Table A, would apply to all new, modified, and reconstructed stationary internal combustion engines as follows:

1. Diesel and dual-fuel engines greater than 560 cubic inch displacement per cylinder (CID/cyl).
2. Gas engines greater than 350 cubic inch displacement per cylinder (CID/cyl) or equal to or greater than eight cylinders and greater than 240 cubic inch displacement per cylinder (CID/cyl).
3. Rotary engines greater than 1500 cubic inch displacement per rotor.

The proposed standards, which would go into effect 30 months after the date of proposal (i.e., today's date), would limit the concentration of NO_x in the exhaust gases from stationary gas, diesel and dual-fuel IC engines to 0.0700 percent by volume (700 ppm), 0.600 percent by volume (600 ppm), and 0.0600 percent by volume 600 ppm, respectively, at 15 percent oxygen (O_2) on a dry basis. These emission limits are adjusted upward linearly for IC engines with thermal efficiencies greater than 35 percent.

Table A.—*Summary of Internal Combustion Engine New Source Performance Standard*

Internal combustion engine size and fuel type	NO_x emission limit* (ppm)	Applicability date
Diesel Engines > 560 CID/cyl or > 1500 CID/rotor	600	30 months from date of proposal (i.e., today's date)
Dual-Fuel Engines > 560 CID/cyl or > 1500 CID/rotor	600	30 months from date of proposal (i.e., today's date)
Gas Engines > 350 CID/cyl or ≥ 8 cylinders *and* > 240 CID/cyl or 1500 > CID/rotor.	700	30 months from date of proposal (i.e., today's date)

*NO_x emission limit adjusted upward for internal combustion engines with thermal efficiencies greater than 35 percent. Measured NO_x emissions adjusted to standard atmospheric conditions of 101.3 Kilopascals (29.92 inches mercury), 29.4 degrees Centigrade (85 degrees Farhenheit), and 17 grams moisture per kilogram dry aid (75 grains moisture per pound of dry air) in determining compliance with the NO_x emission limit.

The proposed standards would be referenced to standard atmospheric conditions of 101.3 kilopascals (29.92 inches mercury), 29.4 degrees centigrade (85 degrees Fahrenheit), and 17 grams mositure per kilogram dry air (75 grains moisture per pound of dry air). Measured NO_x emission levels, therefore, would be adjusted to standard atmospheric conditions by use of ambient correction factors included in the standard. Manufacturers, owners, or operators may also elect to develop custom ambient condition correction factors, in terms of ambient temperature, and/or humidity, and/or ambient pressure. All correction factors would have to be substantiated with data and approved for use by EPA before they could be used for determining compliance with the proposed standards.

Emergency-standby IC engines and all one- and two-cylinder reciprocating gas engines would be exempt from the NO_x emission standard.

Summary of Environmental and Economic Impacts

The proposed standards would reduce uncontrolled NO_x emissions levels from stationary IC engines by about 40 percent. Based on industry growth projections, a reduction in national NO_x emissions of about 145,000 megagrams per year (160,000 tons per year) would

be realized in the fifth year after the standards go into effect. Except for a few local areas (e.g., Los Angeles), there are currently no state standards liminting NO_x emissions from IC engines.

The proposed standards, however, would increase uncontrolled CO and HC emissions levels from stationary IC engines. Based on industry growth projections, an increase in national CO emissions of about 216,000 megagrams (238,000 tons) annually would be realized in the fifth year after the standards go into effect. Similarly, an increase in national total HC emissions of about 4600 megagrams (5000 tons) annually would be realized in the fifth year after the standards go into effect.

The large increase in CO emissions is due primarily to carbureted or naturally aspirated gas engines. These engines operate closer to stoichiometric conditions under which a small change in the air-to-fuel ratio results in a large increase in CO emissions.

Though total national CO emissions would increase significantly, ambient air CO concentrations in the immediate vicinity of these carbureted or naturally aspirated gas engines would not be adversely affected. As a result of the proposed standards of performance, the CO emissions from a naturally aspirated engine would increase about 160 percent. NO_x emissions from the same engine, however, would decrease concurrently about 40 percent.

Thus, there exists a trade-off between NO_x emissions reduction and CO emissions increase, particularly for carbureted or naturally aspirated gas engines. It should be noted though that CO emissions are considered to be a local problem since CO readily reacts to form CO_2. Additionally, most naturally aspirated gas engines are operated in remote locations where CO is not a problem. NO_x emissions, however, are linked to the formation of photochemical oxidants and are subject to long range transport. Also, NO_x emission control techniques are essentially design modifications, not add-on equipment. therefore, NO_x emissions reductions are much harder to achieve than CO or HC emissions reductions which may be achieved more easily from other sources.

One alternative is to propose a CO emissions limit based on the use of oxidizing catalysts. These catalysts can provide CO and HC emissions reductions on the order of 90 percent. Initial capital costs are high, however, averaging about $7500 for a typical 1000 horsepower naturally aspirated gas engine, or about 15 percent of the purchase price of this engine. EPA feels these costs for control of CO emissions are unreasonable.

The trade-off between NO_x and CO emissions appears reasonable. However, EPA invites comments from state and local air pollution control agencies, environmental groups, the industry, and other interested individuals concerning all aspects of the attractiveness of these standards which reduce NO_x emissions at the expense of CO emissions.

Industry has requested a waiver from the national mobile source standards for diesel engines used in light duty vehicles. Based on their tests, industry believes that the application of NO_x control techniques to these mobile diesel engines causes increased particulate (smoke) emissions. The plumes from most well maintained large-bore stationary IC engines, however, are virtually invisible when the engine is operating at steady state. Though excessive retard will cause diesel and dual fuel units to emit smoke, the NO_x control results used in the development of this standard were only considered if the plume did not exceed ten percent visibility. Therefore, EPA feels the NO_x control techniques used to meet the proposed standards for large stationary IC engines will not cause excessive visible and/or particulate emissions. However, EPA invites comments on the aspects of the proposed standards which reduce NO_x emissions at the expense of visible and/or particulate emissions.

There would be essentially no adverse water pollution, solid waste, or noise impact resulting from the proposed standards.

The energy impact of the proposed standards would be small. Turbocharged gas IC engine fuel consumption would be increased about two percent. Dual-fuel IC engine fuel consumption would be increased about three percent. Diesel IC engine fuel consumption would be increased about seven percent. Naturally aspirated gas IC engine fuel consumption would be increased by about eight percent. The fifth year energy impact of the proposed standards would be equivalent to an increase in fuel oil consumption of about 1.5 million barrels of oil per year (4,300 barrels of oil per day). This represents an increase of only 0.03 percent of the oil projected to be imported in the United States five years after the standards go into effect. In addition, these estimates are based on "worse-case" assumptions which yield the greatest energy impacts, and actual impacts are expected to be lower.

The economic impacts of the proposed standards are considered reasonable. The proposed standards would increase IC engine manufacturers' total capital investment requirements for developmental testing of engine models by about $5 million. These expenditures would be made over a two year period. Analysis of financial reports and other public financial information indicates that the manufacturers' overhead budgets are sufficient to support these requirements without adverse impact on their financial positions. The proposed standards would not give rise to a significant sales advantage for one or two manufacturers over competing manufacturers. The maximum intra-industry sales losses, based on "worst-case" assumptions, would be about six percent.

The proposed standards would increase the total annualized costs to users of a large stationary IC engines of all fuel types by about two to seven percent. The capital cost or purchase price of a large stationary IC engine would increase by about two percent.

The proposed standards would increase the total annualized costs for all engine users by about $32 million in the fifth year after standards go into effect. The total capital investment requirements for all users would equal about 9.6 million on a cumulative basis over the first five years the standards are in effect.

These impacts would result in price increases for the end products or services provided by the industrial and commercial users of large stationary IC engines. The electric utility industry would pass on a price increase after five years of 0.02 percent. After five years, delivered natural gas prices would increase 0.04 percent. Even after a full phase-in period of 30 years, during which new controlled engines would replace all existing uncontrolled engines, the electric utility industry would pass on a price increase of only 0.1 percent. Delivered natural gas prices would increase only 0.3 percent.

Rationale—Selection of Source for Control

Stationary IC engines are sources of NO_x, hydrocarbons (HC), particulates, sulfur dioxide (SO_x), and carbon monoxide (CO) emissions. NO_x emissions from IC engines, however, are of more concern than emissions of these other pollutants for two reasons. First, compared to total U.S. emissions for each pollutant, NO_x is the primary pollutant emitted by stationary engines. Second, EPA has assigned a high priority to development of standards of

performance limiting NO_x emissions. A study by Argonne National Laboratory, "Priorities and Procedures for Development of Standards of Performance for New Stationary Sources of Atmospheric Emissions" (EPA–450/3–76–020), concluded that national NO_x emissions from stationary sources would increase by more than 40 percent between 1975 and 1990 in the absence of additional emission controls. Applying best technology to all sources would reduce this increase but would not prevent it from occurring. This unavoidable increase in NO_x emissions is attributable largely to the fact that current NO_x emission control techniques are based on combustion redesign. In addition, few NO_x emission control techniques can achieve large (i.e., in the range of 90 percent) reductions in NO_x emissions. Consequently, EPA has assigned a high priority to the development of standards of performance for major NO_x emission sources wherever significant reductions in NO_x can be achieved. Studies have shown that IC engines are significant contributors to total U.S. NO_x emissions from stationary sources. Internal combustion engines account for 16.4 percent of all stationary source NO_x emissions, exceeded only by utility and packaged boilers.

Studies have investigated the effect that standards of performance would have on nationwide emissions of particulates, NO_x, SO_x, HC, and CO from stationary sources. The "Priority List for New Source Performance Standards under the Clean Air Act Amendments of 1977," which was proposed in the August 31, 1978, **Federal Register**, ranked sources according to the impact, in tons per year, that standards promulgated in 1980 would have on emissions in 1990. This ranking placed spark ignition IC engines second and compression ignition IC engines third on a list of 32 stationary NO_x emission sources. Consequently, stationary IC engines have been selected for development of standards of performance.

Selection of Pollutants

Nitrogen oxides, hydrocarbons, and carbon monoxide.—Stationary IC engines emit the following pollutants: NO_x, CO, HC, particulates, and SO_x. The primary pollutant emitted by stationary IC engines is NO_x, accounting for over six percent (or 16 percent of all stationary sources) of the total U.S. inventory of NO_x emissions.

Stationary IC engines also emit substantial quantities of CO and HC. Numerous small (1–100 hp) spark ignition engines, which are similar to automotive engines, account for about 20 percent of the uncontrolled HC emissions and about 80 percent of the uncontrolled CO emissions. The large annual production of these small spark ignition engines (approximately 12.7 million), however, makes enforcement of a new source performance standard for this group difficult.

Large-bore engines, which account for three-quarters of NO_x emissions from stationary IC engines, contribute relatively small amounts to nationwide HC and CO emissions, especially if one considers that 80 percent of the HC emissions from large-bore IC engines are methane. An additional factor in considering CO and HC control is that inherent engine characteristics result in a trade-off between NO_x control and control of CO and HC.

As mentioned before, in some cases, particularly naturally aspirated gas engines, the application of NO_x emission control techniques could cause increases in CO and HC emissions. This increase in CO and HC emissions is strictly a function of the engine operating position relative to stoichiometric conditions, not the NO_x control technique. These engines operate closer to stoichiometric conditions under which a small change in the air-to-fuel ratio results in a large increase in CO emissions. Any increase in CO and HC emissions, however, represents an increase in unburned fuel and hence a loss in efficiency. Since IC engines manufacturers compete with one another on the basis of engine operating costs, which is primarily a function of engine operating efficiency, the marketplace will effectively ensure that CO and HC emissions are as low as possible following application of NO_x control techniques.

Though total national CO emissions would increase significantly, ambient air CO concentrations in the immediate vicinity of these carbureted or naturally aspirated gas engines would not be adversely affected. As a result of the proposed standards of performance, the CO emissions from a natually aspirated engine would increase about 160 percent. NO_x emissions from the same engine, however, would decrease concurrently about 40 percent.

Thus, there exists a trade-off between NO_x emissions reduction and CO emissions increase, particularly for carbureted or naturally aspirated gas engines. It should be noted though that CO emissions are considered to be a local problem as CO readily reacts to form CO_2. Additionally, most naturally aspirated gas engines are operated in remote locations where CO is not a problem. NO_x emissions, however, are linked to the formation of photochemical oxidants and are subject to long range transport. NO_x emissions reductions are also much harder to achieve than CO or HC emissions reductions which may be achieved more easily from other sources.

In addition, promulgation of CO standard of performance could, in effect, preclude significant NO_x control. NO_x emissions are primarily a function of combustion flame temperature. Decreasing the air-to-fuel ratio of a gas engine lowers the flame temperature and consequently reduces NO_x formation. As will be discussed later, this technique is the most effective means of reducing NO_x emissions from gas engines. CO emissions, however, are primarily a function of oxygen availability. Decreasing the air-to-fuel ratio reduces oxygen availability and consquently increases CO emissions. Hence naturally aspirated gas engines show a pronounced rise in CO emissions as the air-to-fuel mixture becomes richer (i.e., decreasing air-to-fuel ratio). Thus, placing a limit on CO emissions from internal combustion engines could effectively limit the decrease in the air-to-fuel ratio which would be applied to reduce NO_x emissions from naturally aspirated gas engines and, consequently, could limit the amount of NO_x emissions reduction achievable.

One alternative is to propose a CO emissions limit based on the use of oxidizing catalysts. These catalysts can provide CO and HC emissions reductions on the order of 90 percent. Initial capital costs are high, however, averaging about $7500 for a typical 1000 horsepower naturally aspirated gas engine, or about 15 percent of the purchase price of this engine. EPA feels these costs for control of CO emissions are unreasonable.

The trade-off between NO_x and CO emissions appears reasonable, and consequently, only NO_x emissions from large stationary IC engines were selected for control by standards of performance.

EPA, however, invites comments from state and local air pollution control agencies, environmental groups, the industry, and interested individuals concerning all aspects of the attractiveness of these standards which reduce NO_x emissions at the expense of CO emissions.

Particulate.—Virtually no data are available on particulate emission rates from stationary IC engines. It is believed, however, that particulate emissions from stationary IC engines are

very low because the plumes from most of these engines are not visible. Therefore, neither particulate emissions nor visible emissions (plume opacity) were selected for control by standards of performance.

Sulfur oxides.—Sulfur oxides (SO_x) emissions from an IC engine depend on the sulfur content of the fuel and the fuel consumption of the engine. Scrubbing of IC engine exhausts to control SO_x emissions does not appear to be reasonable from an economic viewpoint. Therefore, the only viable means of controlling SO_x emissions would be combustion of low sulfur fuels. IC engines, however, currently burn low-sulfur fuels and will likely continue to do so because of the lower operating and maintenance costs associated with combustion of these fuels. Therefore, SO_x emissions were not selected for control by standards of performance.

Selection of Affected Facilities

A relatively small number of large-bore IC engines account for over 75 percent of all NO_x emissions from stationary engines. The remaining smaller bore IC engines, which make up the majority of all engine sales, are, from a NO_x emission standpoint, a considerably less significant segment of the industry. These engines have different emission characteristics due to their size, design, and operating parameters. The NO_x reduction technology developed for use on the large-bore IC engines may not be directly applicable to these smaller engines. Therefore, at this time, only large-bore engines have been selected for control by standards of performance.

Diesel engines.—The primary high usage (large emissions impact) domestic application of large-bore diesel engines during the past five years has been for oil and gas exploration and production. The market for prime (continuous) electric generation and other industrial applications all but disappeared after the 1973 oil embargo, but was quickly replaced by sales of standby electric units for building services, utilities, and nuclear power stations. The rapid growth in the oil and gas production market occurred because diesel units are being used on oil drilling rigs of various sizes. Sales of engines to export applications have also grown steadily since 1972, and are now a major segment of the entire sales market.

Medium-bore as well as large-bore engines are sold for oil and gas exploration, standby service, and other industrial applications. Applying standards of performance to medium-bore engines serving the same applications as large-bore designs would increase the number of affected facilities from about 200 to about 2,000 units per year (based on 1976 sales information) but consequently further reduce national NO_x emissions. Medium-bore sales accounted for significant NO_x emissions in 1976 (approximately 12,500 megagrams). It is estimated that approximately 25 percent, or about 500 of these units in high usage applications, accounted for most of the medium/bore NO_x emissions, since most of the remainder of these units were sold as standby generator sets. Though the potential achievable NO_x reduction is significant, this alternative causes the standard to apply to lower power engine models with fewer numbers of cylinders competing with other unregulated engines in different stationary markets. Additionally, considering this large number, and the remoteness and mobility of petroleum applications, this alternative would create serious enforcement difficulties. Consequently, a definition is required that distinguishes large-bore engines competing with medium-bore high power engines used for baseload electrical generation from large-bore engines competing solely with other large-bore engines.

One approach would be to define diesel engines covered by standards of performance as those exceeding 560 cubic inch displacement per cylinder (ie., CID/cyl). IC engines below this size are generally used for different applications than those above it. Considering the sizes and displacements offered by each diesel manufacturer and the applications served by diesel engines, this definition was selected as a reasonable approach for separating large-bore engines that compete with medium-bore engines from large-bore engines that compete solely with each other.

Dual-fuel engines.—The concept of dual-fuel operation was developed to take advantage of both compression ignition performance and inexpensive natural gas. These engines have been used almost exclusively for prime electric power generation. Shortages of natural gas and the 1973 oil embargo have combined to significantly reduce the sales of these engines in recent years. The few large-bore units that were sold (11 in 1976) were all greater than 350 CID/cyl.

Although a greater-than-350-CID/cyl limit would subject nearly all new dual-fuel sources to standards of performance, the criterion chosen to define affected diesel engines (i.e., greater than 560 CID/cyl) has also been selected for dual-fuel engines. The primary reason is that supplies of natural gas are likely to become even more scarce; thus dual-fuel engines will likely operate as diesel engines.

Gas engines.—The primary application of large-bore gas engines during the past five years has been for oil and gas production. The primary uses are to power gas compressors for recovery, gathering, and distribution. About 75 to 80 percent of all gas engine horsepower sold during the past five years was used for these applications. During this time, sales to pipeline transmission applications declined. Pipeline applications combined with standby power, electric generation, and other services (industrial and sewage pumping) accounted for the remaining 20 to 25 percent of horsepower sales. The growth of oil and gas production applications during this period corresponds to the increasing efforts to find new, or to recover marginal, gas reserves and distribute them to the existing pipeline transmission network.

It is estimated that the 400,000 horsepower of large-bore gas engine capacity sold for oil and gas production applications in 1976 emitted 35,000 megagrams of NO_x emissions, or nearly three times more NO_x than was emitted by the 200,000 horsepower of large-bore diesel engine capacity sold for the same application in that year. Thus, large-bore gas engines are primary contributors of NO_x emissions from new stationary IC engines, and standards of performance should be directed particularly at these sources.

If affected engines were defined as those greater than 350 CID/cyl, then all competing manufacturers of large-bore gas engines except one would be affected by the proposed standards of performance. This one manufacturer produces primarily medium-bore engines. Therefore, a 350 CID/cyl limit would give this one manufacturer an unfair competitive advantage over other large-bore engine manufacturers. Consequently, this definition should be lowered, or another definition adopted, to include the manufacturer in question. Either of the following two definitions would subject this manufacturer's gas engine to standards of performance:

- Greater than 240 CID/cyl
- Greater than 350 CID/cyl or greater than or equal to 8-cylinder and greater than 240 CID/cyl

Both measures would essentially include only this manufacturer's gas engines which compete with other manufacturer's large-bore gas engines. The second definition has a slight

advantage over the first since it includes only gas engines produced by all manufacturers that have competitor counterparts of about the same power. Therefore, this second definition of affected gas engines was selected.

Rotary engines.—Rotary or wankel type engines have only recently been introduced as power sources in package stationary applications. These internal combustion engines convert energy in the fuel directly to rotary motion rather than through reciprocating pistons and a crankshaft. These engines consist of a triangular rotor rotating eccentrically inside an epitrochoidal housing.

Until recently the largest rotary engine in production was 90 cubic inches per rotor. Now, however, one manufacturer is producing a rotary engine with a displacement of 2,500 cubic inches per rotor. This engine is being offered as a one rotor model rated at 550 horsepower and a two rotor unit rated at 1,100 horsepower.

The displacement of the rotary engine is defined as the volume contained in the chamber, bordered by one flank of the rotor and the housing, at the instant the inlet port closes. These engines are presently sold as naturally aspirated gaseous fueled units primarily for fuel gathering compressors and power generation on offshore platforms.

NO_x emissions from these large rotary engines are similar to NO_x emissions from naturally aspirated four stroke, gaseous fuel reciprocating engines. Further sales of these engines are estimated to be 50,000 horsepower per year over the next five years. Since these large rotary engines contribute to NO_x emissions, standards of performance for new stationary IC engines should include these sources.

Due to design differences, rotary engines develop more power per cubic inch displacement than reciprocating engines. If the lower cutoff limit for affected rotary engines were 350 CID/rotor—in an attempt to equate displacement per cylinder and also use the same limit as for gaseous fueled engines—then rotary engines of approximately 100 horsepower would be regulated by standards of performance. Thus rotary engine manufacturers would be at a competitive disadvantage with unregulated reciprocating engine manufacturers in this power range. To ensure that the standards of performance do not alter the competitive position of the two types of engines, the lower size limit for affected rotary engines should correspond to an engine whose power output is the same as the smallest affected reciprocating unit.

Based on this criterion of equivalent horsepower, it is estimated that rotary engines greater than 1,500 CID/rotor would compete with reciprocating engines greater than 350 CID/cyc. Therefore, a greater than 1,500 CID/rotor definition of affected rotary engines is selected to subject these engines to standards of performance. The definition applies to rotary engines of all fuel types.

Exemptions.—One and two cylinder reciprocating engines could be covered by the above definitions. These engines, however, account for less than 10 percent of all engine horsepower and therefore are less significant NO_x emitters. Additionally, the engines operate at a small fraction of their power output and probably have lower NO_x emissions than the larger, high rated engines. Therefore, all one and two cylinder reciprocating engines were exempted from standards of performance.

Emergency standby engines also require special consideration. These engines operate less than 200 hours per year under all but very unusual circumstances. Consequently, they add relatively little to regional or national total NO_x emissions. The largest category of emergency standby units is for nuclear power plants, where these engines provide power for the pumps used for cooling the reactors. These engines must attain a set speed in ten seconds and must assume full rated load in 30 seconds. In some cases, application of the demonstrated NO_x control technique limits the responsiveness of these engines in emergency situations. Therefore, all emergency standby engines are exempted from standards of performance.

Selection of Best System of Emission Reduction

Four emission control techniques, or combinations of these techniques, have been identified as demonstrated NO_x emission reduction systems for stationary large-bore IC engines. These techniques are: (1) Retarded ignition or fuel injection, (2) air-to-fuel ratio changes, (3) manifold air cooling, and (4) derating power output (at constant speed). In general, all four techniques are applied by changing an engine operating adjustment.

Fuel injection retard is the most effective NO_x control technique for diesel engines. Similarly, air-to-fuel ratio change is the most effective NO_x control technique for gas engines. Both retard and air-to-fuel ratio changes are effective in reducing NO_x emissions from dual-fuel engines.

Other NO_x emission control techniques exist but are not considered feasible alternatives. Of these other techniques, catalytic reduction of NO_x emissions through the use of systems similar to automobile catalyst systems is probably the first to come to mind. Most large stationary IC engines operate at air-to-fuel ratios that are typically much greater than stoichiometric, and consequently the engine exhaust is characterized by high oxygen (O_2) concentrations. Existing automobile catalytic converters, however, operate near stoichiometric conditions (i.e., low exhaust O_2 concentrations). These automobile catalysts are not effective in reducing NO_x in the presence of high O_2 concentrations.

Consequently, entirely different catalyst systems would be needed to reduce NO_x emissions from large stationary IC engines. Although such catalyst systems are currently under development and have been demonstrated for one very narrow application (i.e., fuel-rich naturally aspirated gas engines), they have not been demonstrated for the broad range of IC engines manufactured, such as turbocharged engines, fuel-lean gas engines, or diesel engines. For these engines the reduction of NO_x by ammonia injection over a precious metal (e.g., platinum) catalyst appears promising with NO_x reductions of approximately 90 percent having been reported; however, the cost of such a system is high.

For a typical 1000 horsepower engine approximately two cubic feet of honeycomb catalyst (platinum based) would be required to ensure proper operation of the system. The cost of the catalyst was estimated at $1,500/cubic foot (in 1973). Assuming that the engine costs $150/hp and that the cost of the catalyst accounts for about one-half the cost of the whole system (container, substrate, and catalyst), the capital investment for this control system represents approximately four percent of the engine purchase price.

The amount of ammonia required for an ammonia/catalyst NO_x reduction system will depend on the NO_x emission rate (g/hp-hr). Based on uncontrolled NO_x emission rates of 9 to 22 g/hp-hr, and the cost of $150/ton for the ammonia, the cost impact of injecting ammonia is approximately 5 to 15 percent of the total annual operating costs ($/hp-hr) for natural gas engines. When this operating cost is combined with the capital cost of the catalytic system discussed above, the total cost

increase is about 25 percent. Therefore, in continuous service applications this system is expensive compared to control techniques such as retard or air-to-fuel changes.

It is also important to note that the consumption of ammonia can be expressed as a quantity of fuel since natural gas is generally used to produce ammonia. Assuming a conservative NO_x emission rate of 20 g/hp-hr, and engine heat rate of 7500 Btu/hp-hr, a heating value of 21,800 Btu/lb for natural gas, and a requirement for approximately 900 lbs of gas per ton of ammonia produced, then the ammonia necessary for the catalytic reduction has the same effect on the supply of natural gas as a two percent increase in fuel consumption. Additional fuel is required to operate the plant which produces the ammonia.

Catalytic reduction, therefore, is currently not a demonstrated NO_x emission control technique which could be used by all IC engines. Consequently, although catalytic reduction of NO_x emissions could be used in a few isolated cases to comply with standards of performance, it could not be used as the basis for developing standards of performance which are applicable to all IC engines.

The data and information presented in the Standards Support and Environmental Impact Statement clearly indicate that the four demonstrated control techniques mentioned above will reduce NO_x emissions from IC engines. Due to inherent differences in the uncontrolled emission characteristics of various engines, it is difficult to draw conclusions from this data and information concerning the ability of these emission control techniques to reduce NO_x emissions from all IC engines to a specific level. In general, engines with high uncontrolled NO_x emissions levels have relatively high controlled NO_x emissions levels and engines with low uncontrolled NO_x emissions levels have relatively low contolled NO_x emissions levels. To eliminate these inherent differences in NO_x emission characteristics among various engines, the data were analyzed in terms of the degree of reduction in NO_x emissions as a function of the degree of application of each emission control technique.

Ignition retard in excess of eight degrees in diesel engines frequently leads to unacceptably high exhaust temperatures, resulting in exhaust value and/or turbocharger turbine damage. Similarly, changes in the air-to-fuel ratio in excess of five percent in gas engines frequently lead to excessive misfiring or detonation which could lead to a serious explosion in the exhaust manifold. Eight degrees of ignition retard in diesel engines and five percent change in air-to-fuel ratios in gas engines yield about a 40 percent reduction in NO_x emissions. Consequently, in light of these limitations to the application of these emission control techniques, it is apparent that a 40 percent reduction in NO_x emissions is the most stringent regulatory option which could be selected as the basis for standards of performance. An alternative of 20 percent NO_x emission reduction was also considered a viable regulatory option which could serve as the basis for standards of performance.

Environmental impacts.—Standards of performance based on alternative I (20 percent reduction) would reduce national NO_x emissions by 72,500 megagrams annually in the fifth year after the standards went into effect. In contrast, standards of performance based on alternative II (40 percent reduction) would reduce national NO_x emissions by about 145,000 megagrams annually in the fifth year after the standards went into effect. Thus, standards of performance based on alternative II would have a much greater impact on national NO_x emissions than standards based on alternative I.

Standards of performance based on either alternative would, with the exception of naturally aspirated gas engines, result in a small increase in carbon monoxide (CO) and hydrocarbon emissions (HC) from most engines. A typical diesel engine with a sales-weighted average uncontrolled CO emission level of approximately 2.9 g/hp-hr would experience an increase in CO emissions of about 0.75 g/hp-hr to comply with standards of performance based on alternative I, and an increase of about 1.5 g/hp-hr to comply with standards of performance based on alternative II. Total hydrocarbon emissions would increase a sales-weighted average uncontrolled emission level of 0.3 g/hp-hr by about 0.06 g/hp-hr to comply with standards based on alternative I, and would increase by about 0.1 g/hp-hr to comply with standards of performance based on alternative II.

Similarly, a typical dual-fuel engine with a sales-weighted average uncontrolled CO emission level of approximately 2.7 g/hp-hr would experience an increase in CO emissions of about 1.2. g/hp-hr and about 2.7 g/hp-hr to comply with standards of performance based on alternatives I and II, respectively. Total HC emissions, however, would increase by about 0.3 g/hp-hr from a sales-weighted average uncontrolled level of approximately 2.8 g/hp-hr to comply with standards of performance based on alternative I. To comply with standards of performance based on alternative II total hydrocarbon emissions would decrease by 0.6 g/hp-hr.

A typical turbocharged or blower scavenged gas engine with a sales-weighted average uncontolled CO emission level of approximately 7.7 g/hp-hr would experience an increase in CO emissions of about 1.9 g/hp-hr to comply with standards of performance based on alternative I and about 3.8 g/hp-hr to comply with standards of performance based on alternative II. Total hydrocarbon emissions would increase a sales-weighted average uncontrolled level of approximately 1.9 g/hp-hr by about 0.2 g/hp-hr to comply with standards of performance based on alternative I. To comply with standards of performance based on alternative II total hydrocarbon emissions would increase by about 0.4 g/hp-hr.

A typical naturally aspirated gas engine with a sales-weighted average uncontrolled CO emission level of approximately 7.7 g/hp-hr would experience an increase in CO emissions of about 3.9 g/hp-hr to comply with standards of performance based on alternative I and about 17 g/hp-hr to comply with standards of perfomance based on alternative II. Total hydrocarbon emissions would increase a sales-weighted average uncontrolled level of approximately 1.8 g/hp-hr by about 0.04 g/hp-hr to comply with standards of performance based on alternative I. To comply with standards of performance based on alternative II total hydrocarbon emissions would increase by about 0.08 g/hp-hr.

As noted earlier, the increase in ambient air CO levels resulting from compliance with NO_x standards of performance based on either alternative would be insignificant compared to the NAAQS of 10 mg/m^3 for CO. Additionally, CO emissions are a local problem as CO readily reacts to form CO_2. Additionally, most naturally aspirated engines are operated in remote or sparcely populated areas, CO emissions will not present a problem.

Currently, national stationary CO emissions are approximately 33 million megagrams per year. Standards of performance based on alternative I would increase these emissions by approximately 63,000 megagrams annually in the fifth year after the standards went into effect. In contrast, standards of performance based on alternative II would increase national CO emissions by about 216,000

megagrams annually in the fifth year after the standards went into effect.

Standards of performance based on alternative I would increase national total HC emissions by about 2,300 megagrams annually in the fifth year after the standards went into effect compared to an increase of about 4,600 megagrams annually associated with alternative II. It is estimated that more than 90 percent of total HC emissions from large-bore gas-fuel engines and 75 percent of total HC emissions from large-bore dual-fuel engines are methane, which is nonreactive and does not lead to oxidant formation. Standards of performance based on alternative I would increase national reactive HC emissions by approximately 108 megagrams annually in the fifth year after the standards went into effect, compared to an increase of approximately 216 megagrams annually associated with alternative II.

Stationary IC engines are sources of NO_x, HC, and CO emissions, with both NO_x and HC contributing to oxidant formation. With regard to regulation of emissions from IC engines, NO_x emissions are of more concern than emissions of HC for two reasons. First, NO_x is emitted in greater quantities from stationary IC engines than HC. Second, as mentioned earlier, a high priority has been assigned to development of standards of perfomance limiting NO_x emissions. A study by Argonne National Laboratory, "Priorities and Procedures for development of Standards of Perfomance for New Stationary Sources of Atmospheric Emissions," concluded that national NO_x emissions from stationary sources would increase by more than 40 percent between 1975 and 1990 in the absence of additional emission controls. The slight increase in HC emissions from IC engines associated with control of NO_x can be offset in most cases from other sources more easily than NO_x emissions can be reduced from other sources. Therefore, the adverse enviromental impact of increased HC emissions because of the reduction in NO_x emissions is considered small.

There would be essentially no water pollution, solid waste, or noise impact of standards of performance based on either alternative I or alternative II.

Thus, as reflected in Table I, the environmental impacts of standards of performance based on either alternative are small and reasonable

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TABLE I

ENVIRONMENTAL IMPACTS OF ALTERNATIVES

Pollutant	Base Level[a]	Alternative I	Alternative II
National NO_x Emissions	14.6 x 10^6 megagrams	Reduced by 72,500 megagrams annually in the fifth year after standard goes into effect	Reduced by 145,000 megagrams annually in the fifth year after standard goes into effect
National CO Emissions	33.0 x 10^6 megagrams	Increased by 63,000 megagrams annually in the fifth after standard goes into effect	Increased by 216,000 megagrams annually in the fifth after standard goes into effect
National Total HC Emissions	10.2 x 10^6 megagrams	Total Hydrocarbons Increased by 2,300 megagrams annually in the fifth year after standard goes into effect Reactive Hydrocarbons Increased by 108 megagrams annually in the fifth year after standard goes into effect	Total Hydrocarbons Increased by 4,600 megagrams annually in the fifth year after standard goes into effect Reactive Hydrocarbons Increased by 216 megagrams annually in the fifth year after standard goes into effect
Water Pollution	--	No increase	No increase
Solid Waste	--	No increase	No increase
Noise	--	No adverse impact	No adverse impact

aTotal U.S. emission from stationary sources as per EPA Nationwide Air Pollutant Inventory for 1975

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Energy impacts. The potential energy impact of standards of performance based on either alternative is small. Standards of performance based on alternative I would increase the fuel consumption of a typical blower-scavenged or turbocharged gas engine by approximately one percent, whereas standards of performance based on alternative II would increase the fuel consumption by approximately two percent.

Standards of performance based on alternative I would increase the fuel consumption of a typical dual-fuel engine by about one percent. Standards of performance based on alternative II, however, would increase the fuel consumption by three percent. Standards of performance based on alternative I would increase the fuel consumption of a typical naturally aspirated gas engine by approximately six percent. Standards of performance based on alternative II, however, would increase the fuel consumption by approximately eight percent.

Standards of performance based on alternative I would increase the fuel consumption of a typical diesel engine by approximately three percent. Standards of performance based on alternative II, however, would increase the fuel consumption by approximately seven percent.

The potential energy impact in the fifth year after the standards go into effect, based on alternative I, would be equivalent to an increase in fuel consumption of approximately 1.03 million barrels of oil per year compared to the uncontrolled fuel consumption of IC engines affected by the standards of 31 million barrels per year. The potential energy impact in the fifth year after the standard goes into effect, based on alternative II, would be equivalent to approximately 1.5 million barrels of oil per year.

It should be noted that the largest increase represents only 0.02 percent of the 1977 domestic consumption of crude oil and natural gas. The largest increase also represents only 0.03 percent of the projected total oil imported to the U.S. five years after the standards go into effect.

Thus, the energy impacts of standard of performance based on either alternative are small and reasonable.

Economic impact of alternatives. Manufacturers of stationary IC engines would incur additional costs due to standards of performance. These costs, however, would be small. It is estimated that the total cost to the manufacturers for each engine model family, including development, durability tests, and retooling, would be approximately: (1) $125,000 for retard and air-to-fuel change; (2) $150,000 for manifold air temperature reduction; and (3) $25,000 for derate. For each manufacturer therefor, total costs would vary depending on (1) the number of engine model families produced; (2) their degree of advancement in emission testing; (3) the uncontrolled emission levels of their engines; (4) the development and durability testing required to produce engines that can meet proposed standards of performance; and (5) the emission control technique selected for NO_x emission reduction.

The manufacturer's total capital investment requirements for developmental testing of engine models is estimated to be about $4.5 million to comply with standards of performance based on alternative I and about $5 million to comply with standards of performance based on alternative II. These expenditures would be made over a two year period. Analyses of the financial statements and other public financial information of engine manufacturers or their parent companies indicate that the manufacturer's overhead budgets are sufficient to support the development of these controls without adverse impact on their financial position.

Manufacturers would not experience significant differential cost impacts among competing engine model families. Consequently, no significant sales advantages or disadvantages would develop among competing manufacturers as a result of standards of performance based on either alternative. Based on "worst-case" assumptions, the maximum intra-industry sales losses would be about six percent as a result of standards of performance based on either alternative. Thus, the intra-industry impacts would be moderate and not cause any major dislocations within the industry.

The total annualized cost penalities imposed on IC engines by standards of performace would also have very little impact with regard to increasing sales of gas turbines. Standards of performance based on alternative I would result in no loss of sales to gas turbines whereas standards of performance based on alternative II could result in the possible loss of sales for one diesel manufacturer.

It should be noted that this conslusion is based on limited data. It is quite likely, however, that this manufacturer's line of diesel engines, through minor combustion modifications, could reduce its NO_x emissions as discussed in the SSEIS to levels comparable to those of other manufacturers. Further, due to technical limitations, economic considerations, and customer preference, it is unlikely that IC engine users would switch to gas turbines. Thus, the impact on sales would be minimal.

Therefore, the economic impacts on the manufacturers of standards of performance based on either alternative are considered small and reasonable.

The application of NO_x controls will also increase costs to the engine user. The magnitude of this increase will depend upon the amount and type of emission control applied. Fuel penalties are the major factor affecting this increase.

The following four end uses represent the major applications of diesel, dual-fuel, and natural gas engines: (1) Diesel engine, electrical generation; (2) dual-fuel engine, electrical generation; (3) gas engine, oil and gas transmission and (4) gas engine, oil and gas production.

The manufacturers' capital budget requirements to develop and test engine NO_x control techniques would be regarded as an added expense and most likely passed on to the engine users in the form of higher prices. Therefore, users of IC engines would have to expend additional capital to purchase more expensive engines. This capital cost penalty, however, is small. A two percent increase in engine price would be expected on the average as the result of standards of performance based on either alternative. Typical initial costs for uncontrolled diesel and dual-fuel, electrical generation engines, and natural gas oil and gas transmission engines are about $150/hp. Initial costs for gas, gas production engines are about $50/hp.

The total additional capital cost for all users would equal about $9.6 million on a cumulative basis over the first five years to comply with standards of performance based on either alternative.

As mentioned earlier, fuel penalties are the major factor affecting the total annualized cost of high usage engines. The total annualized cost of a typical uncontrolled diesel, electrical generation engine is about 2.5¢/hp-hr. As a result of standards of performance based on alternative I this total annualized cost would increase by about 0.04¢/hp-hr (1.5 percent). As a result of standards of performance based on alternative II this total annualized cost would increse by about 0.11¢/hp-hr (4.5 percent).

The total annualized cost of a typical uncontrolled dual-fuel electrical generation engine is about 2.8¢/hp-hr. As a result of standards of performance

base on alternative II this total annualized cost would increase by about 0.07¢/hp-hr (2.5 percent). As a result of standards of performance based on alternative Ii this total annualized cost would increase by about 0.09¢/hp-hr (3.2 percent).

The total annualized cost of a typical uncontrolled gas, oil and gas transmission engine is about 2.2¢/hp-hr. As a result of standards of performance based on alternative I this total annualized cost would increase by about 0.02¢/hp-hr (1 percent). As a result of standards of performance based on alternative II this total annualized cost would increase by about 0.04¢/hp-hr (2 percent).

The total annualized cost of a typical uncontrolled gas, oil and gas production engine is about 2.2¢/hp-hr. As a result of standards of performance based on alternative I this total annualized cost would increase by about 0.14¢/hp-hr (6.5 percent). As a result of standards of performance based on alternative II this total annualized cost would increase by about 0.16¢/hp-hr (7.5 percent).

Thus, the total annualized cost penalties to the user associated with either alternative are small. Total uncontrolled annualized costs of about $580 million by all large stationary IC engine users would increase by about $25 million to comply with standards of performance based on alternative I and would increase by about $32 million to comply with standards of performance based on alternative II in the fifth year after the standards go into effect.

The economic impacts on users arising from the cost penalties outlined above would be small. In general, these impacts translate into price increases for the end products or services provided by the industrial and commercial users of large stationary IC engines. The electric utility industry would pass on a price increase after five years of 0.02 percent to comply with standards of performance based on either alternative. After five years, delivered natural gas prices would increase 0.02 percent if standards of performance based on alternative I were applied and 0.04 percent if standards of performance based on alternative II were applied.

Even after a full phase-in period of 30 years, during which new controlled engines would replace all existing uncontrolled engines, the electric utility industry would realize a price increase of only 0.1 percent to comply with standards of performance based on either alternative. Similarly, delivered natural gas prices would increase only 0.1 percent if standards of performance based on alternative I were applied and 0.3 percent if standards of performance based on alternative II were applied. Thus, as summarized in Table II, the economic impacts of standards of performance based on either alternative are considered small and reasonable.

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TABLE II

ECONOMIC IMPACTS OF ALTERNATIVES

Impact	Uncontrolled Level of Cost	Alternative I	Alternative II
Impact on Manufacturer			
Capital budget requirements	--	$4.5 million over two years; able to generate internally from profits.	$5 million over two years; able to generate internally from profits.
Intra-industry competition	--	Maximum sales loss unlikely to exceed 6% of internal combustion engine sales for any firm.	6% maximum loss for any firm
Competition from gas turbines	--	No losses.	Possible sales loss for one diesel manufacturer.
Impact on End-Use Applications			
Total annualized cost[a]			
Diesel fuel, electrical generation	2.5¢/hp-hr	Base increased by 0.04¢/hp-hr	Increased by 0.11¢/hp-hr
Dual-fuel, electrical generation	2.8¢/hp-hr	Increased by 0.07¢/hp-hr	Increased by 0.09¢/hp-hr
Natural gas fuel, oil and gas transmission	2.2¢/hp-hr	Increased by 0.02¢/hp-hr	Increased by 0.04¢/hp-hr
Natural gas fuel, oil and gas production	2.2¢/hp-hr	Increased by 0.14¢/hp-hr	Increased by 0.16¢/hp-hr
Totals of all new engines after 5 years	$580 million	Increased by $25 million	Increased by $32 million
Capital Cost Penalty[a]			
Diesel fuel, electrical generation or dual fuel, electrical generation or natural gas fuel, oil and gas transmission	$150/hp	Increased by $3.00/hp	Increased by $3.00/hp
Natural gas fuel, oil and gas production	$ 50/hp	Increased by $1.00/hp	Increased by $1.00/hp
Totals etc.	$450 million	$9.6 million on a cumulative basis over first 5 years after standards go into effect.	$9.6 million on a cumulative basis over first 5 years after standards go into effect.
Impact on Product Prices and users			
Electricity prices	--	U.S. electric bill up 0.02% after 5 years. U.S. electric bill up 0.1% after full phase-in.	U.S. electric bill up 0.02% after 5 years. U.S. electric bill up 0.1% after full phase-in[b].
Gas prices	--	Delivered natural gas prices up 0.02% after 5 years. Delivered natural gas prices up 0.1% after full phasein.	Delivered natural gas prices up 0.04% after 5 years. Delivered natural gas prices up 0.3% full phasein.

[a] Assumed typical 2000 horsepower engine operating 8000 hours per year in all cases

[b] Full phase-in implies replacement of all existing engines

Based on the assessment of the impacts of each alternative, and since alternative II achieves a greater degree of NO_x reduction, it is selected as the best technological system of continuous emission reduction of NO_x from stationary large-bore IC engines, considering the cost of achieving such emission reduction, any nonair quality health and environmental impact, and energy requirements.

Selection of Format for the Proposed Standards

A number of different formats could be used to limit NO_x emissions from large stationary IC engines. Standards could be developed to limit emissions in terms of: (1) Percent reduction; (2) mass emissions per unit of energy (power) output; or (3) concentration of emissions in the exhaust gases discharged to the atmosphere.

Analysis of the effectiveness of the various NO_x emission control techniques clearly shows that the ability to achieve a percent reduction in NO_x emissions is what has been demonstrated. However, a percent reduction format is highly impractical for two reasons. First, a reference uncontrolled NO_x emission level would have to be established for each manufacture's engine, a difficult task since some manufacturers produce as many as 25 models which are sold with several ratings. Second, a reference uncontrolled NO_x emission level would have to be established for any new engines developed after promulgation of the standard. This would be quite simple for engines that employed NO_x control techniques such as ignition retard or air-to-fuel ratio change to comply with standards of performance. Emissions could be measured without the use of these techniques. For engines designed to comply with the standards through the use of combustion chamber modifications, however, this would not be possible. Thus, new engines would receive no credit for the NO_x emission reduction achieved by combustion chamber redesign and this would effectively preclude the use of this approach to comply with the standards.

A mass-per-unit-of-energy-output format, typically referred to as brake-specific emissions (g/hp-hr), relates the total mass of NO_x emissions to the engine's productivity. Although brake-specific mass standards (g/hp-hr) appear meaningful becasue they relate directly to the quantity of emissions discharged into the atmosphere, there are disadvantages in that enforcement of mass standards would be costly and complicated in practice. Exhaust flow and power output would have to be determined in addition to NO_x concentration. Power output can be determined from an engine dynamometer in the laboratory, but dynamometers cannot be used in the field. Power output could be determined by: (1) Inferring the power from engine operating parameters (fuel flow, rpm, manifold pressure, etc.); or (2) inferring engine power from the output of the generator or compressor attached to the engine. In practice, however, these approaches are time consuming and are less accurate than dynamometer measurements.

Another possible format would be to limit the concentration of NO_x emissions in the exhaust gases discharged to the atmosphere. Concentrations would be specified in terms of parts-per-million volume (ppm) of NO_x. The major advantage of this format is its simplicity of enforcement. As compared to the formats discussed previously, only a minimum of data and calculations are required, which decreases testing costs and minimizes errors in determining compliance with an emission standard since measurements are direct.

The primary disadvantages associated with concentration standards are: (1) A standard could be circumvented by dilution of exhaust gases discharged into the atmosphere, which lowers the concentration of pollutant emissions but does not reduce the total pollutant mass emitted; and (2) a concentration standard could penalize high efficiency engines. Both these problems, however, can be overcome through the use of appropriate "correction" factors.

Since the percent reduction format is impractical, and the problems associated with the enforcement of mass standards (mass-per-unit energy output) appear to outweigh the benefits, the concentration format was selected for standards of performance for large stationary IC engines.

As mentioned above, because a concentration standard can be circumvented by dilution of the exhaust gases, measured concentrations must be expressed relative to some fixed dilution level. For combustion processes, this can be accomplished by correcting measured concentrations to a reference concentration of O_2. The O_2 concentration in the exhaust gases is related to the excess (or dilution) air. Typical O_2 concentrations in large-bore IC engines can range from 8 to 16 percent but are normally about 15 percent. Thus, referencing the standard to a typical level of 15 percent O_2 would prevent circumvention by dilution.

As also mentioned above, selection of a concentration format could penalize high efficiency IC engines. These highly efficient engines generally operate at higher temperature and pressures and, as a result, discharge gases with higher NO_x concentrations than less efficient engines, although the brake-specific mass emissions from both engines could be the same. Thus, a concentration standard based on low efficiency engines could effectively require more stringent controls for high efficiency engines. Conversely, a concentration standard based on high efficiency engines could allow such high NO_x concentrations that less efficient engines would require no controls. Consequently, selecting a concentration format for standards of performance requires an efficiency adjustment factor to permit higher NO_x emissions from more efficient engines.

The incentive for manufacturers to increase engine efficiency is to lower engine fuel consumption. Therefore, the objective of an efficiency adjustment factor should be to give an emissions credit for the lower fuel consumption of more efficient IC engines. Since the fuel consumption of IC engines varies linearly with efficiency, a linear adjustment factor is selected to permit increased NO_x emissions from highly efficient IC engines.

The efficiency adjustment factor needs to be referenced to a baseline efficiency. Most large existing stationary IC engines fall in the range of 30 to 40 percent efficiency. Therefore, 35 percent is selected as the baseline efficiency.

The efficiency adjustment factor included in the proposed standards permits a linear increase in NO_x emissions for engine efficiencies above 35 percent. This adjustment would not be used to adjust the emission limit downward for IC engines with efficiencies of less than 35 percent. This efficiency adjustment factor also applies only to the IC engine itself and not the entire system of which the engine may be a part. Since Section 111 of the Clean Air Act requires the use of the best system of emission reduction in all cases, this precludes the application of the efficiency adjustment factor to an entire system. For example, IC engines with waste heat recovery may have a higher overall efficiency than the IC engine alone. Thus, the application of the efficiency adjustment factor to the entire system would permit greater NO_x emissions because of the system's higher overall efficiency, and would not necessarily require the use of the best demonstrated system emission reduction on the IC engine.

Selection of Numerical Emission Limits

Overall approach.—As mentioned earlier it is difficult to select a specific NO_x emission limit which all IC engines could meet primarily through the use of ignition retard or air-to-fuel ratio change. Because of inherent differences among various IC engines with regard to uncontrolled NO_x emission levels, there exists a rather large variation within the data and information included in the Standards Support and Environmental Impact Statement concerning controlled NO_x emission levels. Generally speaking, engines with relatively low uncontrolled NO_x emissions levels achieved low controlled NO_x emissions levels and engines with high uncontrolled NO_x emissions levels achieved relatively high controlled NO_x emissions levels. Consequently, the following alternatives were considered for selecting the numerical concentration emission limits based on a 40 percent reduction in NO_x emissions:

1. Apply the 40 percent reduction to the highest observed uncontrolled NO_x emission level.

2. Apply the 40 percent reduction to a sales-weighted average uncontrolled NO_x emission level.

3. Apply the 40 percent reduction to this sales-weighted average uncontrolled NO_x emission level plus one standard deviation.

The highest observed uncontrolled NO_x emission levels for gas, dual-fuel and diesel engines are as follows: (1) Gas, 29 g/hp-hr. (2) dual-fuel, 15 g/hp-hr, and (3) diesel, 19 g/hp-hr.

Sales-weighted uncontrolled NO_x emission levels were determined by applying a sales-weighting to each manufacturer's average uncontrolled NO_x emissions for engines of each fuel type. The sales-weighting, based on horsepower sold, gives more weight to those engine models which have the highest sales. The sales-weighted average uncontrolled NO_x emission level for each engine fuel type are as follow: (1) Gas, 15 g/hp-hr. (2) dual-fuel, 8 g/hp-hr, and (3) diesel, 11 g/hp-hr.

The third alternative incorporates a "margin for engine variability" by adding one standard deviation to the sales-weighted average uncontrolled NO_x emission level and then applying the 40 percent reduction. Standard deviations were calculated from the uncontrolled NO_x emission data included in the Standards Support and Environmental Impact Statement, assuming the data had normal distribution. A subsequent statistical evaluation of the data indicated that this assumption was valid. The standard deviations for each engine fuel type are as follows: (1) Gas, 4 g/hp-hr. (2) dual-fuel, 3.2 g/hp-hr. and (3) diesel, 3.7 g/hp-hr.

The standard deviation of the uncontrolled NO_x emission data base is relatively large compared to the sales-weighted average uncontrolled NO_x emission level for each engine type. This indicates that the distribution of uncontrolled NO_x emissions levels is quite broad. In addition, the standard deviation is of the same magnitude as the 40 percent reduction in NO_x emissions that can be achieved. Thus, regardless of which alternative approach is followed to select the numerical NO_x concentration emission limit, a significant portion of the IC engine population may have to achieve more or less than a 40 percent reduction in NO_x emissions to comply with the standards.

It is important to note that the 40 percent reduction in NO_x emissions is based on the application of a single control technique, such as ignition retard, or air-to-fuel ratio change. Other emission control techniques, however, such as manifold air cooling and engine derate, exist, although they are generally not as effective in reducing NO_x emissions. Since emission control techniques are additive to some extent, it is possible in a number of cases to reduce NO_x emissions by greater than 40 percent.

The following factors were examined for each engine type to choose the alternative for selecting the numerical NO_x concentration emission limit: (1) The percentage of engines that would have to reduce NO_x emissions by 40 percent or less to meet the standards; (2) the percentage of engines that would be required to do nothing to meet the standards; and (3) the percentage of engines that would be required to reduce NO_x emissions by more than 40 percent to meet the standards. The normal distribution curve presented in Figure I illustrates the trade-offs among the three alternatives for selecting the numerical NO_x concentration emission limit.

The first alternative is to apply the 40 percent reduction to the highest uncontrolled NO_x emission level within a fuel category. For example, 29 g/hp-hr is the highest uncontrolled NO_x emission level for gas engines. The application of a 40 percent reduction would lead to an emission level of about 17 g/hp-hr. As illustrated in Figure I, if this level were selected as a standard of performance, 99 percent of production gas engines could easily meet the emission limit by reducing emissions by 40 percent or less. However, 69 percent of production engines would not have to reduce NO_x emissions at all. Only one percent of production engines would have to reduce NO_x emissions by more than 40 percent.

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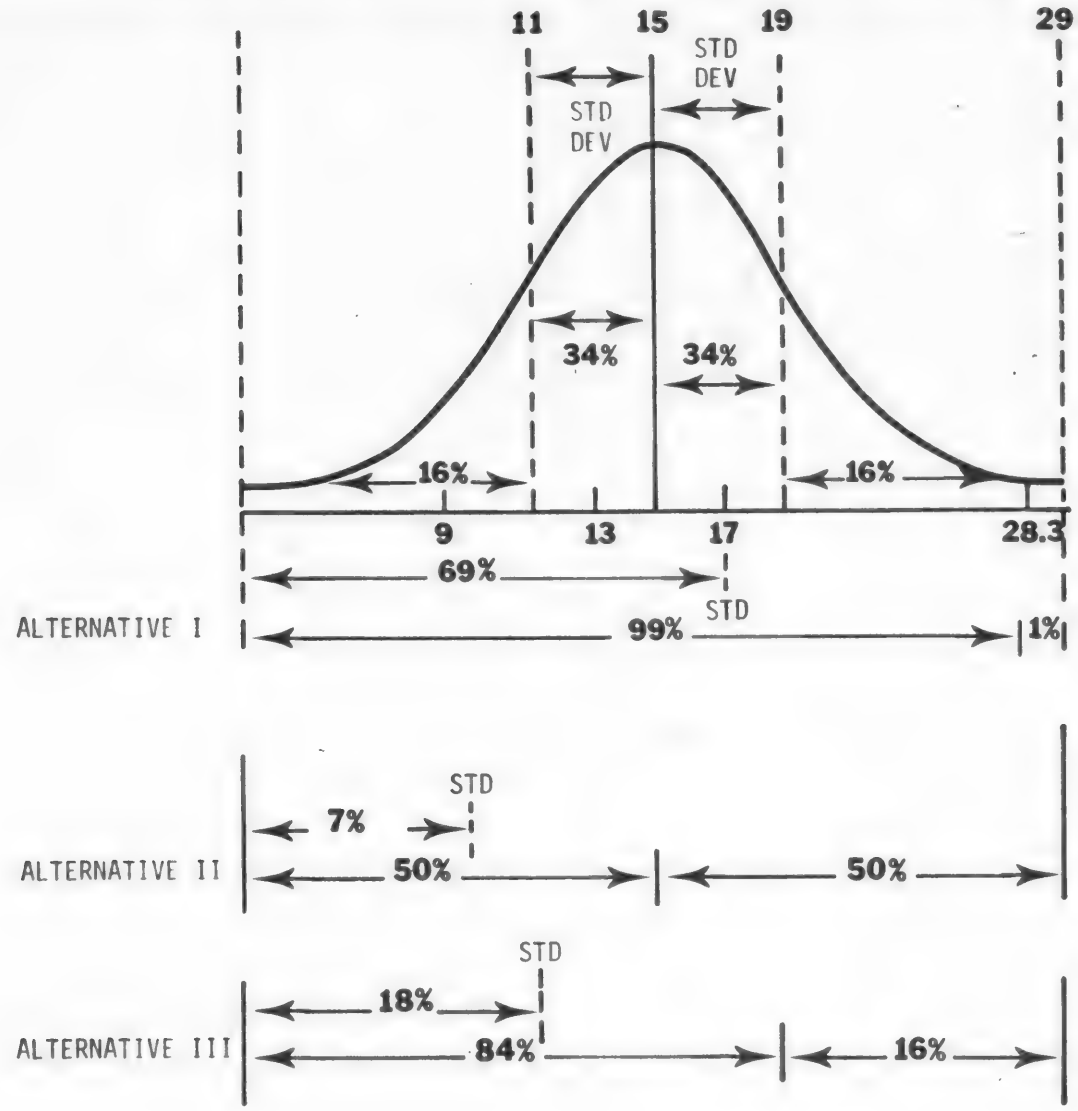

FIGURE 1. Statistical effects of alternative emission limits on gas engines.

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The second alternative is to apply 40 percent reduction to the sales-weighted average uncontrolled NO_x emission level. For example, the sales-weighted avergage uncontrolled NO_x level for gas engines is 15 g/hp-hr. The application of a 40 percent reduction would lead to a NO_x emission level of 9 g/hp-hr. As illustrated in Figure I, if this level were selected as a standard of performance, 50 percent of production gas engines could meet the standard with 40 percent or less reduction in NO_x emissions. However, 50 percent of production gas engines would be required to reduce NO_x emissions by greater than 40 percent. Only seven percent of production gas engines would not have to reduce NO_x emissions at all.

The third alternative is to base the standards on a 40 percent reduction in NO_x emissions from the sales-weighted average uncontrolled NO_x emission level plus one standard deviation. For example, the sales-weighted average uncontrolled NO_x emission level for gas production gas engines is 15 g/hp-hr and the standard deviation of the production gas engine data base is 4 g/hp-hr. Thus, the application of a 40 percent reduction to the sum of these two values would lead to an emission level of 11 g/hp-hr. As illustrated in Figure I, if this level were selected as a standard of performance, 84 percent of the production gas engines could easily meet the emission limit by reducing emissions by 40 percent or less. However, 18 percent of the production gas engines would not have to reduce NO_x emission at all. Only 16 percent of the production gas engines would have to reduce NO_x emissions by more than 40 percent.

This same analysis applied to dual-fuel and diesel engines leads to the results summarized in Table III. If standards of performance were based on Alternative I, essentially all engines could achieve the emission limit by reducing NO_x emissions 40 percent or less. A significant reduction in NO_x emissions would not be achieved, however, since 50 to 70 percent of the IC engines would not have to reduce NO_x emissions at all. If the standards of performance were based on Alternatve II, about 50 percent of the IC engines (in all categories) would have to reduce NO_x emissions by greater than 40 percent. Less than 10 percent would not have to reduce NO_x emissions at all. Thus this alternative would achieve a significant reduction in NO_x emissions from new sources. If standards of performance were based on Alternative III, the results would be similar to those achieved with Alternative I. About 85 percent of engines could easily meet the standards by reducing NO_x emissions by less than 40 percent. About 20 to 30 percent of IC engines would not have to reduce NO_x emissions at all, and about 15 percent of IC engines would have to reduce NO_x emissions by more than 40 percent.

In light of the high priority which has been given to standards directed toward reducing NO_x emissions and the significance of IC engines in terms of their contribution to NO_x emissions from stationary sources, the second alternative was chosen for selecting the NO_x emission concentration limit. This approach will achieve the greatest reduction in NO_x emissions from new IC engines.

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TABLE III

SUMMARY OF STATISTICAL ANALYSES OF ALTERNATE EMISSION LIMITS

GAS ENGINES

Alternative	I	II	III
Standard	17	9	11
Percent required to apply less than or equal to 40 percent control	99	50	84
Percent required to do nothing	69	7	18
Percent required to apply more than 40 percent control	1	50	16

DUAL-FUEL ENGINES

Alternative	I	II	III
Standard	9	5	7
Percent required to apply less than or equal to 40 percent control	98	54	87
Percent required to do nothing	62	18	48
Percent required to apply more than 40 percent control	2	46	13

DIESEL ENGINES

Alternative	I	II	III
Standard	11	7	9
Percent required to apply less than or equal to 40 percent control	98	56	86
Percent required to do nothing	50	4	29
Percent required to apply more than 40 percent control	2	44	14

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Selection of limits.—A concentration (ppm) format was selected for the standards. Consequently, the brake-specific NO_x emission limits corresponding to the second alternative for selecting numerical emission limits (i.e., gas – 9 g/hp-hr; dual-fuel – 5 g/hp-hr; diesel – 7 g/hp-hr) must be converted to concentration limits (corrected to 15 percent O_2 on a dry basis). This may be done by dividing the brake-specific volume of NO_x emissions by the brake-specific total exhaust gas volume. Determining the brake-specific volume of NO_x emissions is straight-forward. Determining the brake-specific total exhaust gas volume is more complex, in that the brake-specific exhaust flow and the exhaust gas molecular weight are unknown. Knowing the fuel heating value and composition, the brake-specific fuel consumption, and assuming 15 percent excess air, however, defines these unknowns. (The complete derivation is explained in detail in the Standards Support and Environmental Impact Statement.) Combining these factors leads to the following conversion factor:

$$NO_x = \frac{\left(\frac{10^6}{46}\right) \times (BSNO_x)}{\left(\frac{16.6 + 3.29\ Z}{12.0 + Z}\right) \times (BSFC)}$$

where:

NO_x = NO_x concentration (ppm) corrected to 15 percent O_2.

$BSNO_x$ = Brake-specific NO_x emissions, g/hp-hr.

BSFC = Brake-specific fuel consumption, g/hp-hr.

Z = Hydrogen/Carbon ratio of the fuel.

For natural gas, a hydrogen-to-carbon (H/C) ratio of 3.5 and a lower heat value (LHV) of 20,000 Btu/lb was assumed. Diesel ASTM–2 has a H/C ratio of 1.8 and a LHV of 18,320 Btu/lb.

Applying this conversion factor to the brake-specific emission limits associated with the second alternative for selecting NO_x emissions limits leads to the NO_x concentration emission limits included in the proposed standards:

Engine:	NO_x emission limit
Gas	700 ppm.
Dual-fuel/Diesel	600 ppm.

These emission limits have been rounded upward to the nearest 100 ppm to include a "margin" to allow for source variability. The standard for diesel engines has also been applied to dual-fuel engines. If a separate emission limit has been selected for dual-fuel engines, the corresponding numerical NO_x concentration emission limit would be 400 ppm. Sales of dual-fuel engines, however, have ranged from 17 to 95 units annually over the past five years, with a general trend of decreasing sales. Dual-fuel engines serve the same applications as diesel engines, and new dual-fuel engines will likely operate primarily as diesel engines because of increasingly limited natural gas supplies. Thus, the combining of dual-fuel engines with diesel engines for standards of performance will have little adverse impact and will simplify enforcement of the standards of performance.

The effect of ambient atmospheric conditions on NO_x emissions from large stationary IC engines can be significant. Therefore, to enforce the standards uniformly, NO_x emissions must be determined relative to a reference set of ambient conditions. All existing ambient correction factors were reviewed that could potentially be applied to large stationary IC engines to correct NO_x emissions to standard conditions.

The correction factors that were selected for both spark ignition (SI) and compression ignition (CI) engines are included in the proposed standards. For the compression ignition engines (i.e., diesel and dual-fuel), a single correction factor for both temperature and humididty was selected. For spark ignition engines (i.e., gas), separate correction factors were selected for humidity and temperature, and measured NO_x emissions are corrected to reference ambient conditions by multiplying these two factors together. No correction factor was selected for changes in ambient pressure because no generalized relationship could be determined from the very limited data that are available. These correction factors represent the general effects of ambient temperature and relative humidity on NO_x emissions, and will be used to adjust measured NO_x emissions during any performance test to determine compliance with the numerical emission limit.

Since the recommended factors may not be applicable to certain engine models, as an alternative to the use of these correction factors, engine manufacturers, owners, or operators may elect to develop their own ambient correction factors. All such correction factors, however, must be substantiated with data and then approved by EPA for use in determining compliance with NO_x emission limits. The ambient correction factor will be applied to all performance tests, not only those in which the use of such factors would reduce measured emission levels.

As discussed in "Standards Support and Environmental Impact Statement: Proposed Standards of Performance for Stationary Gas Turbines," EPA–450/2–77–017a, the contribution to NO_x emissions by the conversion of fuel-bound nitrogen in heavy fuel to NO_x can be significant for stationary gas turbines. The organic NO_x contribution to total gas turbine NO_x emissions is complicated by the fact that the percentage of fuel-bound nitrogen converted to NO_x decreases as the fuel-bound nitrogen level increases. Below a fuel-bound nitrogen level of about 0.05 percent, essentially 100 percent of the fuel-bound nitrogen is converted to NO_x. Above a fuel-bound nitrogen level of about 0.4 percent, only about 40 percent is converted to NO_x.

As discussed in the Standards Support and Environmental Impact Statement, Volume I for Stationary Gas Turbines, assuming a fuel with 0.25 percent weight fuel-bound nitrogen (which allows approximately 50 percent availablility of domestic heavy fuel oil), controlled NO_x emissions would increase by about 50 ppm due to the contribution to NO_x emissions of fuel-bound nitrogen. In gas turbines, this contribution was significant when compared to the proposed emission limit of 75 ppm. However, for large IC engines, the contribution of fuel-bound nitrogen to NO_x emissions is likely to be small (approximately 10 percent). Sales of IC engines firing heavy fuels is insignificant and not expected to increase in the near future. Given that the emission limits have been rounded upward to the nearest 100 ppm and the potential contribution of fuel-bound nitrogen to NO_x emissions is very small, no allowance has been included for the fuel-bound nitrogen content of the fuel in determining compliance with the standards of performance.

Selection of Compliance Time Frame

Manufacturers of large-bore IC engines are generally committed to a particular design approach and, therefore, conduct extensive research, development, and prototype testing before releasing a new engine model for sale. Consequently, these manufacturers will require some period of time to alter or reoptimize and test IC engines to meet standards of performance. The estimated time span between the decision by a manufacturer to control NO_x emissions from an engine model and start of production of the first controlled engine is about 15 months for any of the four demonstrated emission control techniques. With their present facilities, however, testing can typically

be conducted on only two to three engine models at a time. Since most manufacturers produce a number of engine models, additional time is required before standards of performance become effective. In addition, a number of manufacturers produce their most popular engine models at a fairly steady rate of production and satisfy fluctuating demands from inventory. Consequently, additional time in necessary to allow manufacturers to sell their current inventory of uncontrolled IC engines before they must comply with standards of performance.

It is estimated that about 30 months delay in the applicability date of the standard is appropriate to allow manufacturers time to comply with the proposed standards of performance. In addition, in light of the stringency of the standards (i.e., many engine models will have to reduce NO_x emissions by more than 40 percent) this time period provides the flexibility for manufacturers to develop and use combinations of the control techniques upon which the standards are based or other control techniques. Consequently, 30 months from today's date is selected as the delay period for implementation of these standards on large stationary IC engines.

Selection of Monitoring Requirements

To provide a means for enforcement personnel to ensure that an emission control system installed to comply with standards of performance is properly operated and maintained, monitoring requirements are generally included in standards of performance. For stationary IC engines, the most straightforward means of ensuring proper operation and maintenance would be to monitor NO_x emissions released to the atmosphere.

Installed costs, however, for continuous monitors are approximately $25,000. Thus the cost of continuous NO_x emission monitoring is considered unreasonable for IC engines since most large stationary IC engines cost from $50,000 to $3,000,000 (i.e., 1000 hp gas production engine and 20,000 hp electrical generation engine).

A more simple and less costly method of monitoring is measuring various engine operating parameters related to NO_x emissions. Consequently, monitoring of exhaust gas temperature was considered since this parameter could be measured just after the combustion process during which NO_x is formed. However, a thorough investigation of this approach showed no simple correlation between NO_x emission and exhaust gas temperature.

A qualitative estimate of NO_x emissions, however, can be developed by measuring several engine operating parameters simultaneously, such as spark ignition or fuel injector timing, engine speed, and a number of other parameters. These parameters are typically measured at most installations and thus should not impose an additional cost impact. For these reasons, the emission monitoring requirements included in the proposed standards of performance require monitoring various engine operating parameters.

For diesel and dual-fuel engines, the engine parameters to be monitored are: (1) Intake manifold temperature; (2) intake manifold pressure; (3) rack position; (4) fuel injector timing; and (5) engine speed. Gas engines would require monitoring of (1) intake manifold temperature; (2) intake manifold pressure; (3) fuel header pressure; (4) spark timing; and (5) engine speed.

Another parameter that could be monitored for gas engines is the fuel heat value, since it can affect NO_x emissions significantly. Because of the high costs of a fuel heating value monitor, and the fact that many facilities can obtain the lower heating value directly from the gas supplier, monitoring of this parameter would not be required.

The operating ranges for each parameter over which the engine could operate and in which the engine could comply with the NO_x emission limit would be determined during the performance test. Once established, these parameters would be monitored to ensure proper operation and maintenance of the emission control techniques employed to comply with the standards of performance.

For facilities having an operator present every day these operating parameters would be recorded daily. For remote facilities, where an operator is not present every day, these operating parameters would be recorded weekly. The owner/operator would record the parameters and, if these parameters include values outside the operating ranges determined during the performance test, a report would be submitted to the Administrator on a quarterly basis identifying these periods as excess emissions. Each excess emission report would include the operating ranges for each parameter as determined during the performance test, the monitored values for each parameter, and the ambient air conditions.

Selection of Performance Test Method

A performance test method is required to determine whether an engine complies with the standards of performance. Reference Method 20, "Determination of Nitrogen Oxides, Sulfur Dioxide, and Oxygen emissions from Stationary Gas Turbines," which was proposed in the October 3, 1977 **Federal Register**, is proposed as the performance test method for IC engines. Reference Method 20 has been shown to provide valid results. Consequently, rather than developing a totally new reference test method, Reference Method 20 would be modified for use on IC engines.

The changes and additions to Reference Method 20 required to make it applicable for testing of internal combustion engines include (by section):

1. *Principle and Applicability.* Sulfur dioxide measurements are not applicable for internal combustion engine testing.

6.1 Selection of a sampling site and the minimum number of traverse points.

6.11 Select a sampling site located at least five stack diameters downstream of any turbocharger exhaust, crossover junction, or recirculation take-offs and upstream of an dilution air inlet. Locate the sample site no closer than one meter or three stack diameters (whichever is less) upstream of the gas discharge to the atmosphere.

6.1.2 A preliminary O_2 traverse is not necessary.

6.1.2.2 Cross-sectional layout and location of traverse points use a minimum of three sample points located at positions of 16.7, 50 and 83.3 percent of the stack diameter.

6.2.1 Record the data required on the engine operation record on Figure 20.7 of Reference Method 20. In addition, record (a) the intake manifold pressure; (b) the intake manifold temperature; (c) rack position; (d) engine speed; and (e) injector or spark fuming. (The water or steam injection rate is not applicable to internal combustion engines.)

NO_x emissions measured by Reference Method 20 will be affected by ambient atmospheric conditions. Consequently, measured NO_x emissions would be adjusted during any performance test by the ambient condition correction factors discussed earlier, or by custom correction factors approved for use by EPA.

The performance test may be performed either by the manufacturer or at the actual user operating site. If the test is performed at the manufacturer's facility, compliance with that performance test will be sufficient proof

of compliance by the user as long as the engine operating parameters are not varied during user operation from the settings under which testing was done.

Public Hearing

A public hearing will be held to discuss these proposed standards in accordance with section 307(d)(5) of the Clean Air Act. Persons wishing to make oral presentations should contact EPA at the address given in the ADDRESSES Section of this preamble. Oral presentations will be limited to 15 minutes each. Any member of the public may file a written statement with EPA before, during, or within 30 days after the hearing. Written statement should be addressed to Mr. Jack R. Farmer (see ADDRESSES Section).

The docket is an organized and complete file of all the information considered by EPA in the development of this rulemaking. The principal purposes of the docket are (1) to allow interested parties to identify and locate documents so that they can intelligently and effectively participate in the rulemaking process, and (2) to serve as the record for judicial review. The docket requirement is discussed in section 307(d) of the Clean Air Act.

Miscellaneous

As prescribed by Section 111 of the Act, this proposal is accompanied by the Administrator's determination that emissions from stationary IC engines contribute to air pollution which causes or contributes to the endangerment of public health or welfare, and by publication of this determination in this issue of the **Federal Register.** In accordance with section 117 of the Act, publication of these standards was preceded by consultation with appropriate advisory committees, independent experts, and federal department and agencies. The Administrator welcomes comments on all aspects of the proposed regulations, including the designation of stationary IC engines as a significant contributor to air pollution which causes or contributes to the endangerment of public health or welfare, economic and technological issues, monitoring requirements and the proposed test method.

Comments are specifically invited on the severity of the economic and environmental impact of the proposed standards on stationary naturally aspirated carbureted-gas IC engines since some parties have expressed objection to applying the proposed standards to these engines. Comments are also invited on the selection of rotary engines for control by standards of performance. These engines were included because they are expected to be contributors to NO_x emissions from stationary sources and can be controlled by demonstrated NO_x emission control techniques. Any comments submitted to the Administrator on these issues, however, should contain specific information and data pertinent to an evaluation of the magnitude of this impact, its severity, and its consequences.

It should be noted that standards of performance for new sources established under section 111 of the Clean Air Act reflect:

> The degree of emission limitation and the percentage reduction achievable through application of the best technological system of continuous emission reduction which (taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated [section 111(a)(1)].

Although there may be emission control technology available that can reduce emissions below those levels required to comply with standards of performance, this technology might not be seclected as the basis of standards of performance because of costs associated with its use. Accordingly, standards of performance should not be viewed as the ultimate in achievable emission control. In fact, the Act may require the imposition of a more stringent emission standard emission in several situations.

For example, applicable costs do not necessarily play as prominent a role in determining the "lowest achievable emission rate" for new or modified sources located in nonattainment areas (i.e., those areas where statutorily mandated health and welfare standards are being violated). In this respect, section 173 of the Act requires that new or modified sources constructed in an area which exceeds the National Ambient Air Quality Standard (NAAQS) must reduce emissions to the level which reflects the "lowest achievable emission rate" (LAER), as defined in section 171(3). The statute defines LAER as that rate of emissions which reflects:

> (A) The most stringent emission limitation which is contained in the implementation plan of any state for such class or category of source, unless the owner or operator of the proposed source demonstrates that such limitations are not achievable or
>
> (B) The most stringent emission limitation which is acheved in practice by such class or category of source, whichever is more stringent.

In no event can the emission rate exceed any applicable new source performance standard.

A similar situation may arise under the prevention-of-significant-deterioration-of-air-quality provisions of the Act. These provisions require that certain sources employ "best available control technology" (BACT) as defined in section 169(3) for all pollutants regulated under the Act. Best available control technology must be determined on a case-by-case basis, taking energy, environmental and economic impacts, and other costs into account. In no event may the application of BACT result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to section 111 (or 112) of the Act.

In all cases, State Implementation Plans (SIP's) approved or promulgated under section 110 of the Act must provide for the attainment and maintenance of NAAQS designed to protect public health and welfare. For this purpose, SIP's must in some cases require greater emission reduction than those required by standards of performance for new sources.

Finally, states are free under section 116 of the Act to establish even more stringent emission limits than those established under section 111 or those necessary to attain or maintain the NAAQS under section 110. Accordingly, new sources may in some cases be subject to limitations more stringent than standards of performance under section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

Under EPA's "new" sunset policy for reporting requirements in regulations, the reporting requirements in this regulation will automatically expire five years from the date of promulgation unless EPA takes affirmative action to extend them.

EPA will review this regulation four years from the date of promulgation. This review will include an assessment of such factors as the need for integration with other programs, the existence of alternative methods, enforceability, and improvements in emissions control technology.

An economic impact assessment has been prepared as required under section 317 of the Act and is included in the Standards Support and Environmental Impact Statement.

Dated: July 11, 1979.

Douglas M. Costle.

Administrator.

It is proposed to amend Part 60 of Chapter I, Title 40 of the Code of Federal Regulations as follows:

1. By adding Subpart FF as follows:

Subpart FF—Standards of Performance for Stationary Internal Combustion Engines

Sec.

60.320 Applicability and designation of affected facility.
60.321 Definitions.
60.322 Standards for nitrogen oxides.
60.323 Monitoring of operations.
60.324 Test methods and procedures.

Authority: Secs. 111 and 301(a) of the Clean Air Act, as amended, (42 U.S.C. 1857c–7, 1857g(a)), and additional authority as noted below.

Subpart FF—Standards of Performance for Stationary Internal Combustion Engines

§ 60.320 Applicability and designation of affected facility.

The provisions of this subpart are applicable to the following affected facilities which commence construction beginning 30 months from today's date:

(a) All gas engines that are either greater than 350 cubic inch displacement per cylinder or equal to or greater than 8 cylinders and greater than 240 cubic inch displacement per cylinder.

(b) All diesel or dual-fuel engines that are greater than 560 cubic inch displacement per cylinder.

(c) All rotary engines that are greater than 1500 cubic inch displacement per rotor.

§ 60.321 Definitions.

As used in this subpart, all terms not defined herein shall have the meaning given them in the Act or in subpart A of this part.

(a) "Stationary internal combustion engine" means any internal combution engine, except gas turbines, that is not self propelled. It may, however, be mounted on a vehicle for portability.

(b) "Emergency standby engine" means any stationary internal combustion engine which operates as a mechanical or electrical power source only when the primary power source for a facility has been rendered inoperable during an emergency situation.

(c) "Reference ambient conditions" means standard air temperature (29.4°C, or 85°F), humidity (17 grams H_2O/kg dry air, or 75 grains H_2O/lb dry air), and pressure (101.3 kilopascals, or 29.92 in. Hg.).

(d) "Peak load" means operation at 100 percent of the manufacturer's design capacity.

(e) "Diesel engine" means any stationary internal combustion engine burning a liquid fuel.

(f) "Gas enine" means any stationary internal combustion engine burning a gaseous fuel.

(g) "Dual-fuel engine" means any stationary internal combustion engine that is burning liquid and gaseous fuel simultaneously.

(h) "Unmanned engine" means any stationary internal combustion engine installed and operating at a location which does not have an operator regularly present at the site for some portion of a 24-hour day.

(i) "Non-remote operation" means any engine installed and operating at a loction which has an operator regularly present at the site for some portion of a 24-hour day.

(j) "Brake-specific fuel consumption" means fuel input heat rate, based on the lower heating value of the fuel, expressed on the basis of power output (i.e., (kJ/w-hr).

(k) "Weekly basis" means at seven day intervals.

(l) "Daily basis" means at 24 hours intervals.

(m) "Rotary engine" means any Wankel type engine where energy from the combustion of fuel is converted directly to rotary motions instead of reciprocating motion.

(n) "Displacement per rotor" means the volume contained in the chamber of a rotary engine between one flank of the rotor and the housing at the instant the inlet port is closed.

§ 60.322 Standards for nitrogen oxides.

(a) On and after the date on which the performance test required to be conducted by § 60.8 is completed, no owner or operator subject to the provisions of this subpart shall cause to be discharged into the atmosphere, except as provided in paragraphs (b) and (c) of this section—

(1) From any gas engine, with a brake-specific fuel consumption at peak load more than or equal to 10.2 kilojoules/watt-hour any gases which contain nitrogen oxides in excess of 700 parts per million volume, corrected to 15 percent oxygen on a dry basis.

(2) From any diesel or dual-fuel engine with a brake-specific fuel consumption at peak load more than or equal to 10.2 kilojoules/watt-hour any gases which contain nitrogen oxides in excess of 600 parts per million volume, corrected to 15 percent oxygen on a dry basis.

(3) From any stationary internal combustion engine with a brake-specific fuel consumption at peak load of less than or equal to 10.2 kilojoules/watt-hour any gases which contain nitrogen oxides in excess of:

$$\text{(i)}\quad STD = 700\,\frac{10.2}{Y}\ \text{for any gas engine,}$$

$$\text{(ii)}\quad STD = 600\,\frac{10.2}{Y}\ \text{for any diesel or dual-fuel engine}$$

where:

STD = allowable NO_x emissions (parts-per-million volume corrected to 15 percent oxygen on a dry basis).

Y = manufacturer's rated brake-specific fuel consumption at peak load (kilojoules per watt-hour) or owner/operator's brake-specific fuel consumption at peak load as determined in the field.

(b) All one and two cylinder reciprocating gas engines are exempt from paragraph (a) of this section.

(c) Emergency standby engines are exempt from paragraph (a) of this section.

§ 60.323 Monitoring of operations.

(a) The owner or operator of any stationary internal combustion engine, subject to the provisions of this subpart must, on a weekly basis for unmanned engines and on a daily basis for manned engines, monitor and record the following parameters. All monitoring systems shall be accurate to within five percent and shall be approved by the Administrator.

(1) For diesel and dual-fuel engines:
(i) Intake manifold temperature
(ii) Intake manifold pressure
(iii) Engine speed
(iv) Diesel rack position (fuel flow)
(v) Injector timing

(2) For gas engines:
(i) Intake manifold temperature
(ii) Intake manifold pressure
(iii) Fuel header pressure
(iv) Engine speed
(v) Spark ignition timing

(b) For the purpose of reports required under § 60.7(c), periods of excess emissions that shall be reported are defined as any daily (for manned engines) or weekly (for unmanned engines) period during which any one of the parameters specified under paragraph (a) of this section falls outside the range identified for that parameter udner § 60.324(a)(3). Each excess emission report shall include the range identified for each operating parameter under § 60.324(a)(4), the monitored value for each operating parameter specified under § 60.323(a),

the ambient air conditions during the period of excess emissions, and any graphs and/or figures developed under § 60.324(a)(4)

(Sec. 114 of the Clean Air Act, as amended (42 U.S.C. 1857c–9))

§ 60.324 Test methods and procedures.

The reference methods in Appendix A to this part, except as provided in § 60.8(b), shall be used to determine compliance with the standards prescribed in § 60.322 as follows:

(a) Reference Method 20 for the concentration of nitrogen oxides and oxygen. The span for the nitrogen oxides analyzer used in this method shall be 1500 ppm.

(1) The following changes and additions (by section) to Reference Method procedures should be followed when determining compliance with § 60.322:

1. *Principle and Applicability.* Sulfur dioxide measurements are not applicable for internal combustion engine testing.

6.1 Selection of a sampling site and the minimum number of traverse points.

6.11 Select a sampling site located at least five stack diameters downstream of any turbocharger exhaust, crossover junction, or recirculation take-offs and upstream of any dilution air inlet. Locate the sample site no closer than one meter or three stack diameters (whichever is less) upstream of the gas discharge to the atmosphere.

6.1.2 a preliminary O_2 traverse is not necessary.

6.2 Cross-sectional layout and location of traverse points. Use a minimum of three sample points located at positions of 16.7, 50 and 83.3 percent of the stack diameter.

6.2.1 Record the data required on the engine operation record on Figure 20.7 of Reference Method 20. In addition, record (a) the intake manifold pressure; (b) the intake manifold temperature; (c) rack position, fuel header pressure or carburetor position; (d) engine speed; and (e) injector or spark timing. (The water or steam injection rate is not applicable to internal combustion engines.)

(2) The nitrogen oxides emission level measured by Reference Method 20 shall be adjusted to reference ambient conditions by the following ambient condition correction factors:

NO_x corrected = (K) NO_x observed

where K is determined as follows:

Fuel	Correction Factor
Diesel and Dual-Fuel	$K = 1/(1 + 0.00235(H - 75) + 0.00220\ (T - 85))$
Gas	$K = (K_H)\ (K_T)$ $K_H = 0.844 + 0.151\ (\frac{H}{100}) + 0.075\ (\frac{H}{100})^2$ $K_T = 1 - (T - 85)(0.0135)$

where:

H = observed humidity, grains H_2O/lb dry air

T = observed inlet air temperature, °F

The adjusted NO_x emission level shall be used to determine compliance with § 60.322.

(3) Manufacturers, owners, or operators may develop custom ambient correction factors in terms of ambient air temperature and/or pressure, and/or humidity to adjust the nitrogen oxide emission level measured by the performance test to reference ambient conditions. These correction factors must be substantiated with data and must be approved by the Administrator before they can be used to determine compliance with § 60.322. Notices of approval of custom ambient condition correction factors will be published in the **Federal Register.**

(4) Testing shall be conducted and ranges identified for each parameter specified under § 60.323(a) over which the numerical emission limits included under § 60.322 are not exceeded. This will be accomplished by measuring NO_x emissions, using Reference Method 20, and these parameters at four points over the normal load range of the internal combustion engine, including the minimum and maximum points in the range if the stationary internal combustion engine will be operated over a range of load conditions.

(b) ASTM D–2382 shall be used to determine the lower heating value of liquid fuels and ASTM D–1826 shall be used to determine the lower heating value of gaseous fuels.

(Sec. 114 of the Clean Air Act, as amended (42 U.S.C. 1857c–9))

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ENVIRONMENTAL PROTECTION AGENCY

[FRL 1099-6]

Air Pollution Prevention and Control; Addition to the List of Categories of Stationary Sources

Section 111 of the Clean Air Act (42 U.S.C. 1857c-6) directs the Administrator of the Environmental Protection Agency to publish, and from time to time revise, a list of categories of stationary sources which he determines may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare. Within 120 days after the inclusion of a category of stationary sources in such list, the Administrator is required to propose regulations establishing standards of performance for new and modified sources within such category. At present standards of performance for 27 categories of sources have been promulgated.

The Administrator, after evaluating available information, has determined that stationary internal combustion engines are an additional category of stationary sources which meets the above requirements. The basis for this determination is discussed in the preamble to the proposed regulation that is published elsewhere in this issue of the **Federal Register.** Evaluation of other stationary source categories is in progress, and the list will be revised from time to time as the Administrator deems appropriate. Stationary internal combustion engines are included on the proposed NSPS priority list (published August 31, 1978) required by section 111(f)(1), but since the priority list is not final, stationary internal combustion engines are also being listed as indicated below at this time. Once the priority list is promulgated, all source categories on the promulgated list are considered listed under section 111(b)(1)(A), and separate listings such as this will not be made for those source categories.

Accordingly, notice is given that the Administrator, pursuant to section 111(b)(1)(A) of the Act, and after consultation with appropriate advisory committees, experts and Federal departments and agencies in accordance with section 117(f) of the Act, effective July 23, 1979 amends the list of categories of stationary sources to read as follows:

List of Categories of Stationary Sources and Corresponding Affected Facilities

* * * * *

Source Category

* * * * *

Affected Facilities

Internal combustion engines

Proposed standards of performance applicable to the above source category appear elsewhere in this issue of the **Federal Register.**

Dated: July 11, 1979.

Douglas M. Costle,

Administrator./

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